

ON THE CLASSIFICATION OF THE UNIONIDÆ.

BY CHAS. T. SIMPSON.

In the August and September numbers of the *Nautilus*, Dr. von Ihering takes exception to the classification of the Unionidæ proposed by me in the Synopsis, claiming that it is based essentially on the marsupia.

He has apparently overlooked the fact that it is founded not merely on the characters of the marsupia, but on the more obvious anatomical characters, as well as those of the shell and the beaks. It agrees with what I believe to be the development of the family from the earliest and simplest forms to the latest and most highly organized.

So far as the classification of the Diplodontinæ is concerned we essentially agree. This I divided into two supergeneric groups founded on characters of the beak sculpture and shell, and *not* on those of the marsupia. Von Ihering agrees with me that the earliest uniones probably had radial beak sculpture. I have examined the animals of a large number of the South American and Australasian uniones and in all cases where they were gravid the embryos filled the inner gills alone, forming a smooth pad, the ovisacs not being separated by sulci. I have examined a few specimens of the forms with zigzag radial beak sculpture (*Rosanoramphus*), and found in the gravid ones that the marsupia filled the inner gills only. It may be, and probably is the case, that in rare instances among the Hyrianae there are a few embryos in the outer gills. I know of no special characters employed in the classification of large groups which do not vary somewhat, but I believe it still to be a fact that in the Hyrianae the embryos are almost invariably contained in the inner gills only, that in the Unioninæ they are found in the outer, or (in the Tetragenæ) all four of the gills.

In the South American and Australasian Uniones we have the radial beak sculpture with simple shells and the embryos contained within the inner gills, the ovisacs not being separated by any external markings. I believe that these are the simplest and lowest forms of Unione life, that they have descended almost unchanged from the earliest forms of the family. The fact that they occupy the Southern Hemisphere exclusively while the Unioninæ, containing

the more highly developed forms, belong entirely in the Northern Hemisphere, would indicate this. I consider the radial beak sculpture a character belonging to the older and simpler forms; the concentric beak sculpture belongs to the more recent and higher forms. The zigzag radial sculpture of the group *Rosanoramphus* is a move in the direction of concentric sculpture, hence of a higher order than that which is strictly radial.

The *Tetragenæ* is a transition group. *Its young are contained in all four of its gills, filling them throughout*, though they are more numerous as a rule in the outer than in the inner, and this fact together with the general character of the shells and the beak sculpture, which is generally more nearly concentric than radial, led me to place these forms in the *Unioninæ* rather than to make a separate sub-family for them. *In every case where I have placed a form in this group the shell has deep beak cavities.* In the genus *Pleurobema*, which seems to be the next step in the way of development, while the shells are generally rather short, solid and inflated as in *Quadrula*, *the beak cavities are invariably shallow*, and in all cases that I have examined *the outer gills only contain embryos.* Here we have characters of the marsupia agreeing with those of the shells. Care must be taken in the examination of the marsupia or appearances may lead to wrong conclusions. According to von Ihering, Sterki has found *Quadrula heros* with only the hinder part of the outer gills filled with embryos. I have seen the same thing in other *Quadrulas*. I have seen in some of the *Unionidæ* the front part of the gills filled with embryos while all the rest was empty, and in a number of cases a few ovisacs in the middle or in various parts of the gills entirely empty, while the rest were full, or a few filled while all the rest were empty. In such cases the empty ones had simply been discharged, the full ones had not. In all the forms which I have mentioned so far the marsupia fill the entire gills and are pad-like, that is, the ovisacs are not marked out separately by sulci.

Advancing a little in the development of the family we find a number of aberrant forms confined to the Mississippi and Gulf drainages of the United States. Each group has certain characters of the shells which we may call generic, though they are not striking. But they are all very wonderful in the character of their marsupia. In such groups as *Ptychobranthus*, *Cyprogenia* and *Strophitus*, the marsupia are astonishing, and in all of them the ovasacs are distinctly marked.

To this point, proceeding upward in the scale of development, the shells of males and females are essentially alike. It is true that there is some variation in their forms, but it is equally true that somewhat elongated specimens with no inflation at the post-basal part of the shell may be females, while shorter specimens that are full post-basally may be males. I do not think there is any strict dimorphism up to this point. In many cases among these lower forms I have assorted my material before opening it, placing in one lot those I would naturally suppose were males, and in another the presumed females, and on opening the shells and examining the animals I always found I was as likely to be wrong as right. In some groups, notably *Nodularia* and *Lamellidens*, all the shells of certain species are inflated at the post-basal region.

Above this point the shells begin to be regularly dimorphic. They are less regularly so in *Obovaria*, *Medionidus*, some forms of *Nephronaias* and *Plagiola*; they are nearly always dimorphic in *Lampsilis* and *Truncilla*. The shells of male and female are always so different that the merest tyro could without difficulty separate them.

Von Ihering believes that the *Unio tuberculatus* of Barnes is nearly related to the *U. forsheyi* and *U. speciosus* of Lea. I am surprised at such an opinion, because, while the shells of the two last-mentioned forms are alike in male and female, those of the former are strictly and remarkably dimorphic, that of the female being more compressed and ending posteriorly in a wide, rounded wing. That of the male is more inflated, is truncate behind, and has no wing at all. In the animal of the female there is a wide, rounded flap of the mantle which fills this peculiar extension of the shell, differing somewhat from that of any other that I know of.

Now among all these higher forms comprised in the group *Heterogena* there is a radical difference in the marsupia. Wherever I have been able to examine them, they occupy only the posterior portion of the outer gills in the form of distinctly-marked ovisacs. Each ovisac when filled is rounded below. The higher the form ranks, the more markedly is the marsupium swollen and separated from the rest of the gill, and the more distinctly is the female shell swollen in the post basal region to correspond with it. In some forms of *Plagiola* and *Medionidus* there is little difference between male and female shells. In such cases the marsupium, though having the characteristic ovisacs, is but

slightly fuller than the rest of the gill. In the more highly organized species of *Lampsilis*, both the shell of the female and the marsupium are decidedly produced behind. In *Truncilla*, which I regard as the highest manifestation of Unione life, the marsupium is almost absolutely separated from the rest of the gill, and when full, assumes the shape of a great kidney, projecting below the rest of the branchiæ. The great flap of the mantle of the female is very peculiar, being double or having a strong over-hanging ridge inside. In many of the shells of this genus the area corresponding with and covering the marsupium is greatly swollen, is thin, has a different texture from the remainder, is gaping and distinctly toothed.

I have never been able to examine a gravid female of the *Unio tuberculatus* of Barnes, hence I cannot give anything more than a guess as to the character of its marsupium, though from some material lately seen, in which the ovisacs appeared to have just been emptied, I am inclined to believe that the outer gills are filled throughout with embryos, forming well-marked ovisacs.

Now these remarkable characters of a distinctly separated marsupium occupying only the hinder part of the outer gills, and a corresponding swelling of the female shell to receive it, the fact that the more distinct and swollen the marsupium is the more pronounced is the swelling of the shell, may be merely the work of chance; they may stand for nothing whatever in the way of rank or development among our Uniones, but it does not seem so to me. All the changes of shell and marsupium which I have indicated seem to me to be steps in the development of the family from the lowest, simplest and oldest forms to the highest, most complex and most recent.

I need not occupy space with a discussion on the validity or proper determination of species. Such questions are after all largely matters of personal judgment, and in this branch of the work I have endeavored to do the best I possibly could with the material I have been permitted to examine.

Dr. von Ihering changes the subfamilies Unioninæ and Diplodoninæ into families, and divides the former into three sub-families, Unionidæ, Quadrulinæ and Lampsilinæ. He gives no characters for these sub-families, and I am totally at a loss to know on what he would found them. Certainly he cannot establish them on beak sculpture, for in nearly all the species this is more or less concentric, and it seems to me does not offer distinctions sufficiently important to be used as a basis for founding sub-families.

This classification is not founded on characters of the marsupia, for he has placed in *Quadrulinæ* groups in which the embryos occupy all four of the gills, others in which they fill only the outer gills, and still others where they are confined to the hinder or the median part of the outer gills. Besides, he distinctly states on page 39 that a systematic arrangement of the marsupia does not coincide with a natural arrangement of the family.

Nor do I see how such an arrangement can be based on shell characters. *Obovaria*, which is placed with *Quadrula*, has more or less perfectly developed dimorphism in the shells. In *O. ellipsis* the female shells are almost always swollen at the posterior base, and the same is the case with *O. lens* and *O. circulus*, while in *O. castaneus* the male and female shells are as distinct as in any species of *Lampsilis*. *Ptychobranchus*, with its wonderfully folded marsupium occupying the entire outer gills, with the shells of male and female alike, he places in the genus *Lampsilis*. Why he does so I do not know, as the group differs most decidedly from *Lampsilis* in the characters of shell, marsupium and animal.

On the other hand, he places *Truncilla personata* Say, *T. perplexa* Lea, and *T. foliata* Hild., in the genus *Quadrula*! To me such an arrangement is absolutely astonishing! The male shell of the first-named species is somewhat triangular, and does resemble a *Quadrula* somewhat. The female shell is very different, being quadrate and having a decided, gaping, toothed post-basal swelling. In *T. perplexa* the female shell has a great rounded post-basal swelling, which differs in thickness, texture and color from the rest of the shell. I do not think there is a species known in which the differences between the male and female shells are so great as they are in *T. foliata*. In the male shell at the place where there is a compressed, radial, central area the outline of the female is carried down into an enormous and elongated, rounded wing. That these should belong in a genus in which the shells of male and female are alike and from which the animal and marsupium so widely differ, is beyond my comprehension! If such an arrangement is a natural one then I am sure that all the years I have spent in patiently and lovingly studying the Naiades have been absolutely wasted. It seems to me that we might just as well go back to the arrangement temporarily adopted by Dr. Lea, of grouping together in one lot those forms which have a wing, and in another those which have none, and subdividing these groups into small ones founded on form and sculpture of the shell.

I have no doubt that a careful histological study of the branchiæ and perhaps other parts of the animals of the Unionidæ will furnish additional characters for classification. But it will be many years before this can be done, and when it is, I feel sure that the results of such study will fully agree with the characters of the shells and marsupia.

HOW POTAMIDES (CERETHIDEA) CALIFORNICA HALD. TRAVELS.

BY MRS. M. BURTON WILLIAMSON.

In traveling over the mud-flats, *Cerethidea californica* Hald. leaves zigzag marks upon the sandy mud. These lines are made by the apical whorls of the shell as it is dragged forward, or sideways. How does the animal crawl? It *appears* to move forward by the contraction of the foot only, but my observations have led me to the conclusion that the foot movement is somewhat secondary. The movement of this tapering shell is one requiring considerable muscular strength. This is very apparent. In order to study the mode of travel of this species, a specimen was studied as it traveled up the sides of a glass jar of sea-water, and this and other specimens were studied for several hours. The conclusion reached was, that first there was a strong muscular movement forward, then the foot advanced. The Cerethidea pushes its head forward while the tentacles are expanded to their full extent, the body whorl is raised with an effort, then the shell is propelled *forward before the foot advances*. Immediately, no time is lost, the foot is spread out its full capacity and drawn forward. This is immediately followed by a contraction of the foot in the posterior part, then the head is again advanced. The strength of the animal seems to be concentrated in the movement of the body-whorl as it is raised up and forward. Of course all these movements are rapid, so that it requires close observation to see that all movements are not simultaneous, or at least which is secondary. A homely illustration may be used to make this movement plainer. When a man attempts to step upon a ladder with a hod full of bricks, or plaster, his first movement is apt to be a hunching of the shoulders—the weight being